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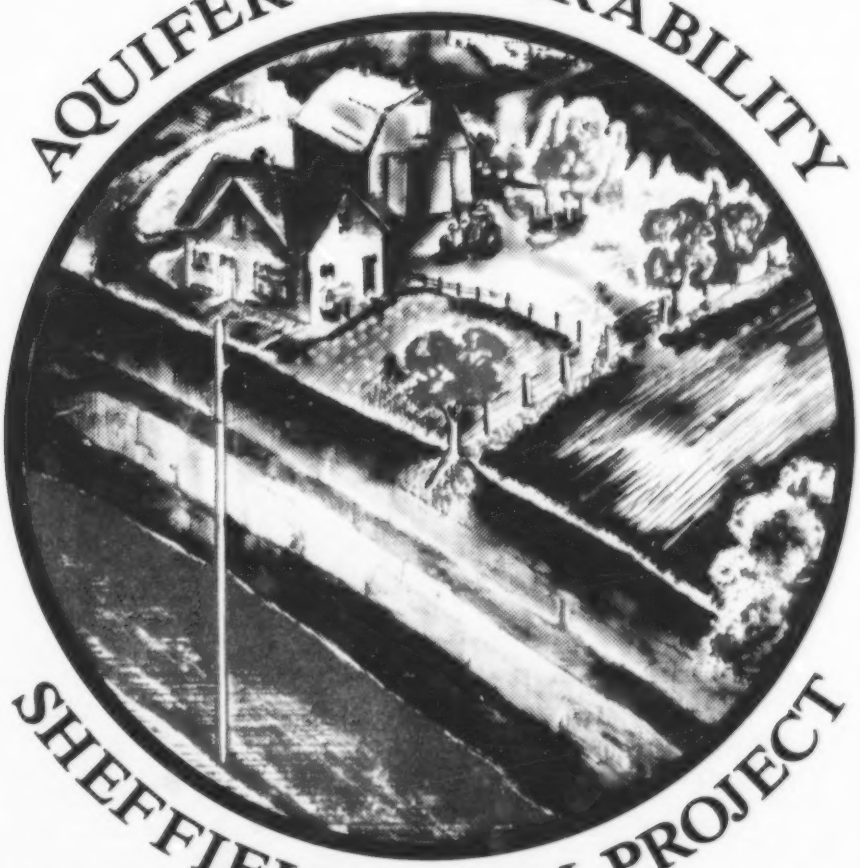

SHEFFIELD FARM PROJECT

BACKGROUND AND OUTLINE

CONSERVATION & PROTECTION

INLAND WATERS DIRECTORATE
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WATER PLANNING AND MANAGEMENT BRANCH
DARTMOUTH, NOVA SCOTIA

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AQUIFER VULNERABILITY

SHEFFIELD FARM PROJECT

BACKGROUND AND OUTLINE

COVER ARTWORK
BY
P. JOHN BURDEN
RICE POINT
PRINCE EDWARD ISLAND

Water Planning & Management Branch
Inland Waters Directorate
Conservation & Protection
Environment Canada

July 1989
Dartmouth
Nova Scotia

Preface

Over the last several years there has been considerable discussion within Conservation and Protection, Atlantic, regarding the federal role in groundwater. Until recently the federal response to groundwater concerns in this Region had been ad hoc with no consolidated framework to guide the use of resources or to focus on priorities.

In 1987, a Groundwater Strategy and Action Plan for the Atlantic Region was adopted. During the development of this Strategy and Action Plan the federal responsibilities in groundwater were reviewed, the need for and importance of consultations with other government departments and the provinces were outlined, and five particular areas of groundwater needs were identified. One of the high priority issues that required immediate attention was in the area of work-shared studies to evaluate toxic chemicals and their occurrence in groundwater.

In addition, the Federal Water Policy released in 1987 also focussed on the federal role and responsibilities with respect to the management of toxic chemicals, water quality management, groundwater contamination and safe drinking water. Pesticide occurrences in groundwater in Eastern Canada and inadequate information bases on this resource were addressed in this policy statement. One of the commitments made with respect to toxics, water quality and groundwater relates to the conduct of research and to provide information and advice on groundwater issues.

This Aquifer Vulnerability Project on the Sheffield Farm is a response to the need for a coordinated approach among federal departments to address the question of groundwater contamination. The interest expressed in the work on this project by federal, provincial and university water specialists indicates not only the importance but the timeliness of pursuing such a study. I believe there will be many opportunities to develop our skills in both the technical side of the work as well as to sharpen our coordinating abilities among the agencies with varying expertise to work together effectively.

T.W. Hennigar, P.Eng.
Groundwater Activities Coordinator
Conservation & Protection, Atlantic

Executive Summary

Environment Canada, in co-operation with Agriculture Canada, is developing a pro-active or anticipatory programme to determine the environmental behaviour of pesticides and nitrates under Atlantic Canadian conditions. This approach is intended to provide interested parties with the needed protocols for evaluating the chemistry and fate of agrichemicals, particularly as they relate to the new guidelines for the registration of pesticides in Canada. Also, to determine under what agricultural practices particular pesticides and fertilizers can be applied without causing unacceptable contamination of groundwaters. Certain pesticides suspected of being soluble and persistent enough to contaminate groundwaters will be subjected to controlled field applications.

The Sheffield Farm Research Station, located 5 kilometres north of Kentville in the Annapolis-Cornwallis Valley of Nova Scotia, was chosen as a suitable aquifer vulnerability study area. A large part of the farm is covered with well drained sandy loams that are frequently used for potato, berry, tobacco and orchard crops. The aquifers beneath these permeable soils are vulnerable to contamination by pesticide and fertilizer residues.

Specific controlled field experiments will be conducted upon completion of site instrumentation. Suggested experiments include a follow-up to the Prince Edward Island aldicarb monitoring, a second experiment on the use of insecticides or fumigants that have been detected in British Columbia groundwaters and a third experiment involving the application of atrazine to corn crops which is heavily used in the region. A limited number of as yet unregistered herbicides may also be available for experimentation.

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1.0 INTRODUCTION

Environment Canada, in co-operation with Agriculture Canada, is developing a pro-active or anticipatory programme to determine the environmental behavior of pesticides and nitrates under climatic, physiographic and soil conditions found in Atlantic Canada. This approach is intended to provide interested parties with the needed protocols for evaluating the chemistry and fate of agrichemicals, particularly as they relate to the new guidelines for the registration of pesticides in Canada. Another goal is to determine under what agricultural practices, particular pesticides and fertilizers can be applied without causing unacceptable contamination of groundwaters. Certain pesticides suspected of being soluble and persistent enough to contaminate groundwaters will be subjected to controlled field applications.

To this end, a Memorandum of Understanding was signed with Agriculture Canada to conduct a five year study at their Sheffield Farm Research Station in the Annapolis-Cornwallis Valley of Nova Scotia. The terms and conditions in the MOU are included in Appendix 1. The farm was chosen because it provides optimal study conditions. These include good project control since it is a federal facility and a research station, good logistics (e.g. close to IWD Atlantic headquarters, available support facilities), and is representative of agricultural conditions in the Annapolis Valley. The well drained sandy loams on the farm are typical of valley soils supporting a variety of crops including potatoes, berries, tobacco and orchards.

2.0 SITE DESCRIPTION

The Sheffield Farm site is located five kilometres north of the Agriculture Canada Kentville Research Station in the Annapolis-Cornwallis Valley. Figures 1 and 2 show the station and farm location. The farm has a cool, humid climate with a total annual precipitation of 1116 mm of which 227 mm is snowfall. Most precipitation falls between October and February. The summer growing season is characterized by average daily maximum temperatures of 16.1 C in May to 24.9 C in July. Monthly precipitation during these three months averages 73 mm (after Langille, 1987).

The Farm is located on the floor of the Annapolis-Cornwallis Valley and is bisected by a natural drainage channel (Figure 3). The soils of the Farm have developed from glaciofluvial, fluviomarine and till deposits. These overlie Triassic Wolfville bedrock (Figure 4), which consist of mainly poorly sorted and cross stratified sandstones and conglomerates with intraformational claystone and siltstone (Trescott, 1968).

A large part of the Farm is covered with well drained sandy loams of the Cornwallis and Somerset soil series, as shown on Figure 5. The aquifers beneath these permeable soils are vulnerable to contamination by pesticide and fertilizer residues. As such, the soils provide attractive sites in which to conduct experimental applications of pesticides and fertilizers to crops in order to assess the migration and fate of the residues with respect to groundwaters.

Figure 6 shows the field number system used by Agriculture Canada on the Sheffield Farm. Three field areas have been identified as potential sites for pesticide application:

1. field area B1/C1 (Somerset),
2. field area B4 (Somerset), and
3. field area E4/E5/E6/D5/D6 (Cornwallis).

The codes (A,B,C and D) used by Environment Canada to identify piezometer sites are a simplified version from those quoted above and used by Agriculture Canada.

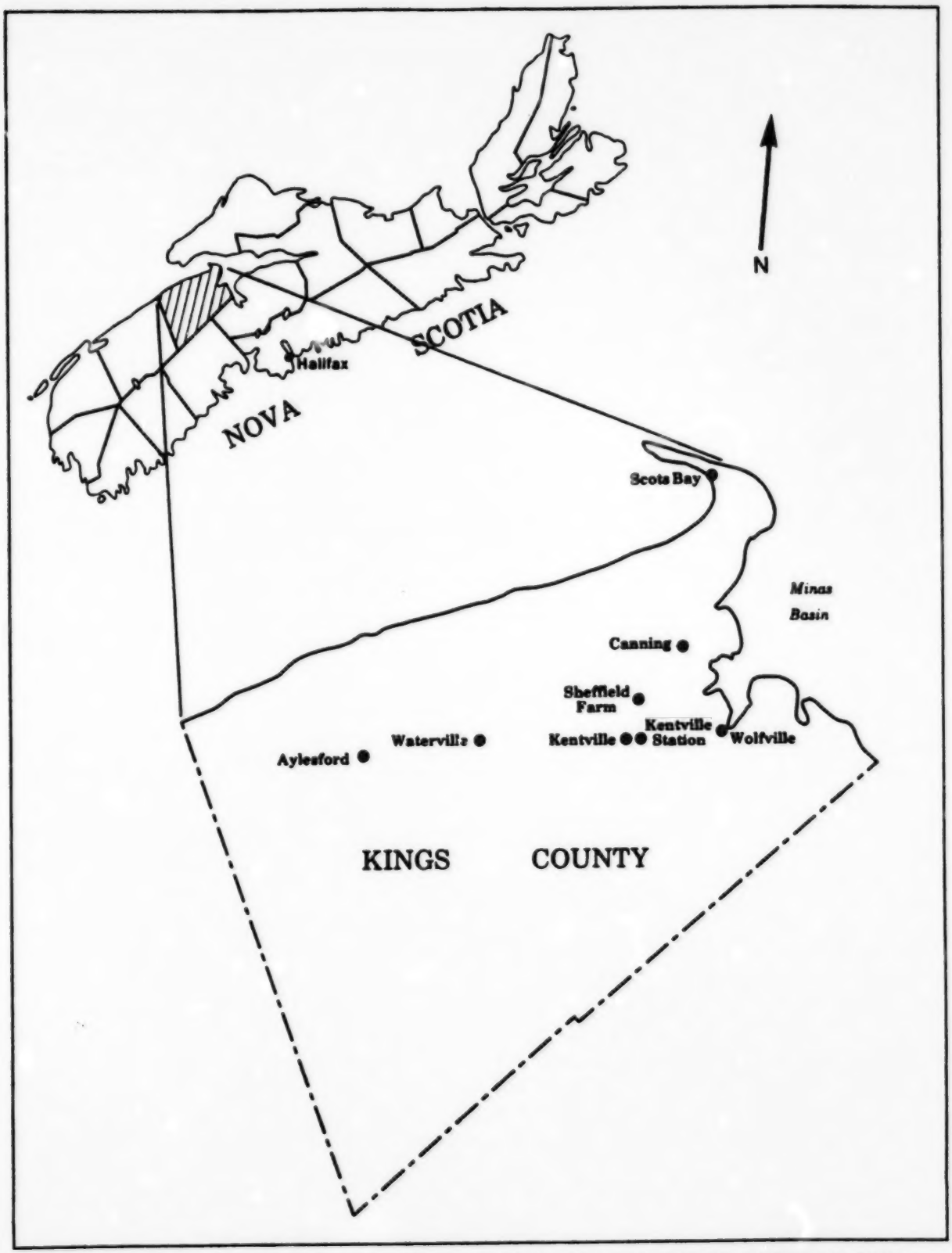


FIG. 1 GENERAL LOCATIONS OF THE KENTVILLE RESEARCH STATION AND SHEFFIELD FARM.

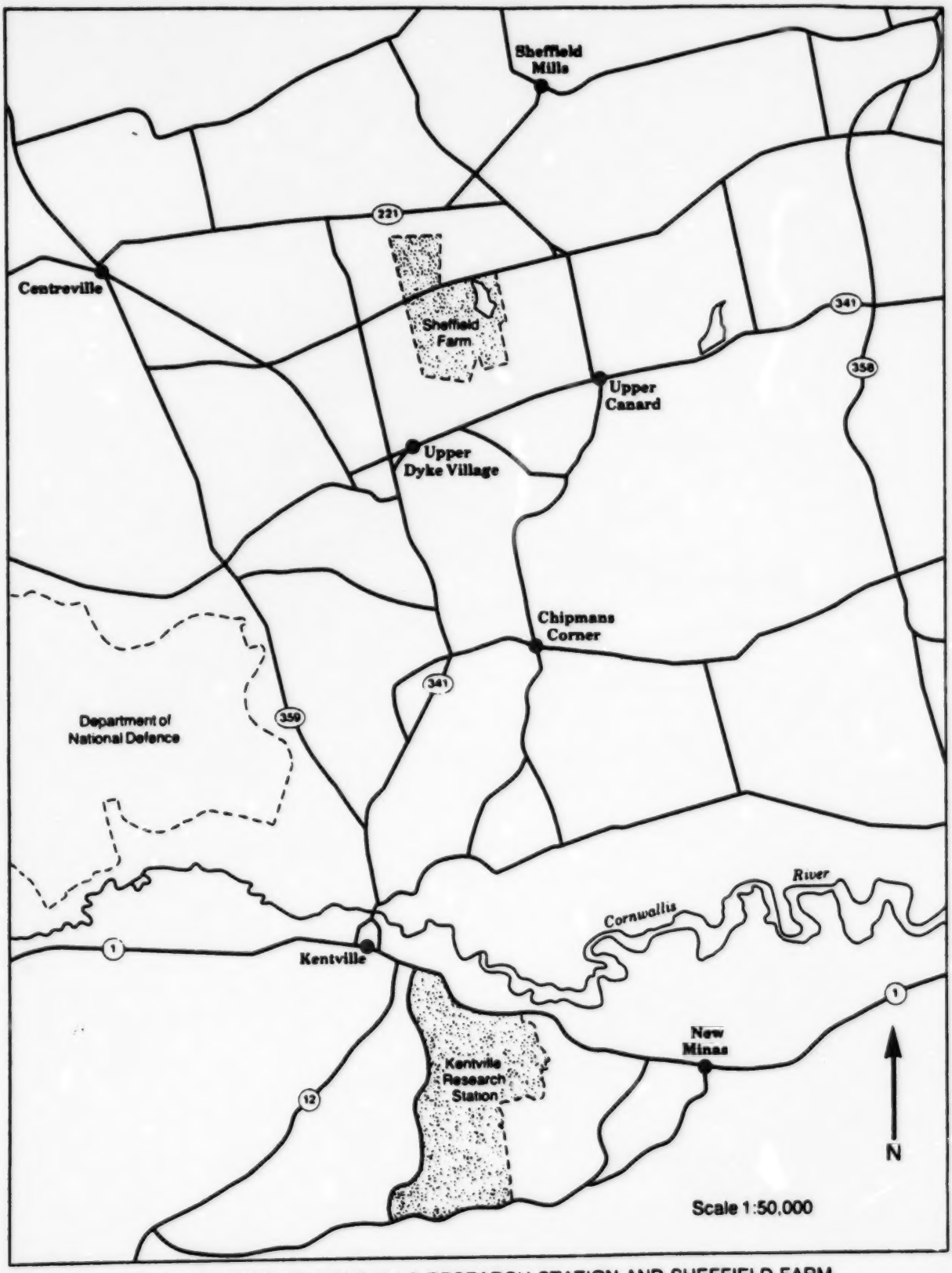


FIG. 2 LOCATION OF KENTVILLE RESEARCH STATION AND SHEFFIELD FARM.

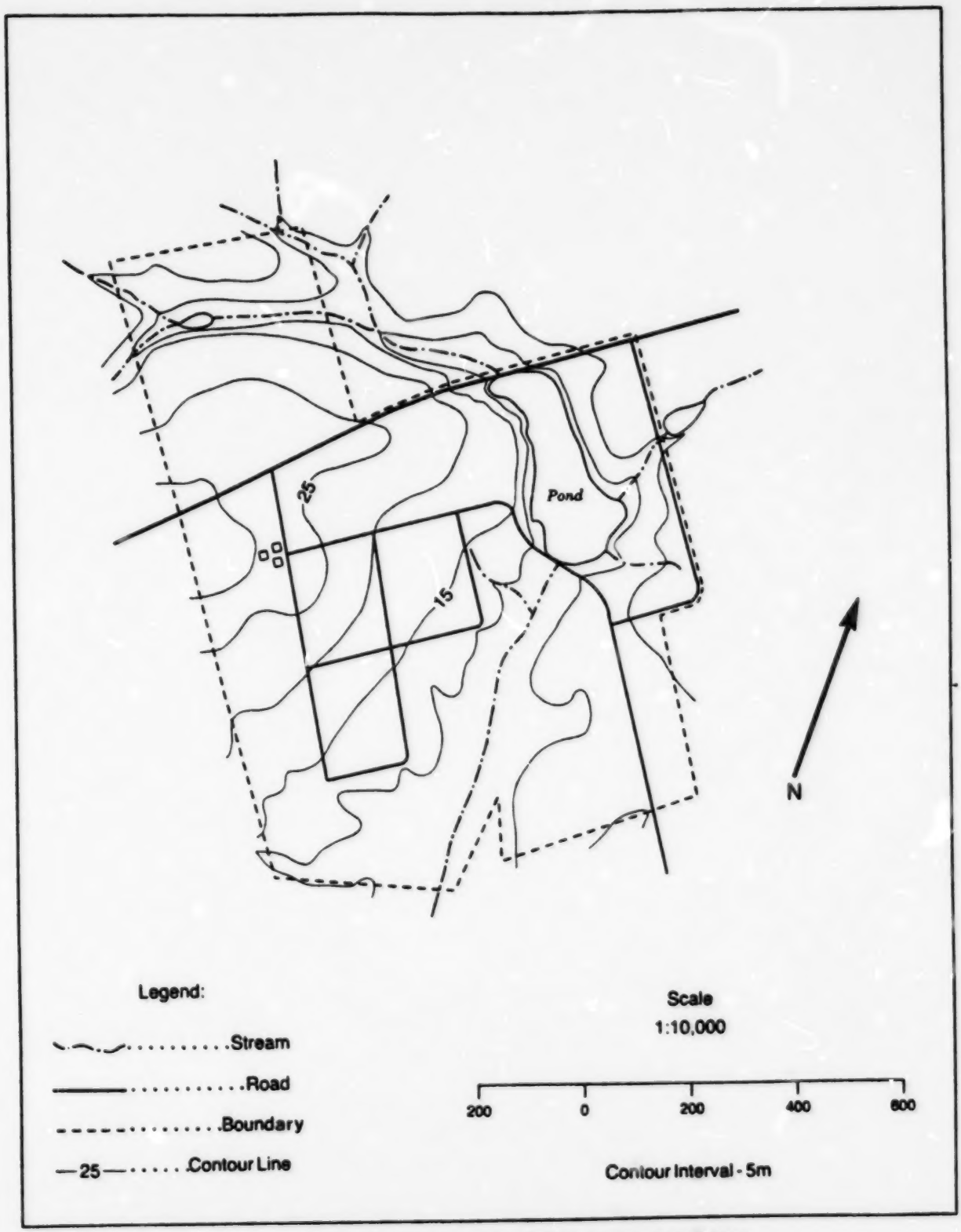
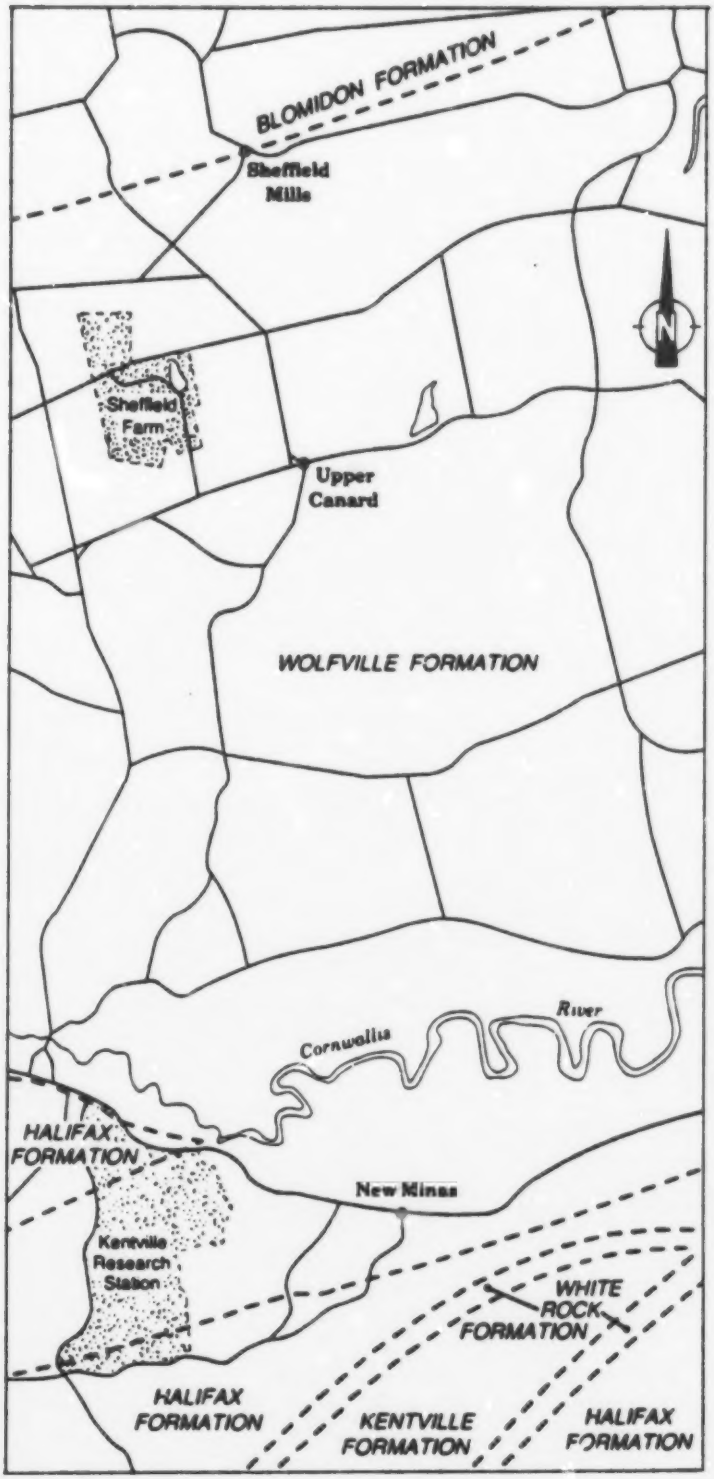


FIG. 3 RELIEF AND DRAINAGE OF THE SHEFFIELD FARM.



---- FORMATION BOUNDARY

APPROXIMATE SCALE 1:77,500

FIG. 4 GEOLOGIC FORMATIONS UNDERLYING THE SURVEY AREA.

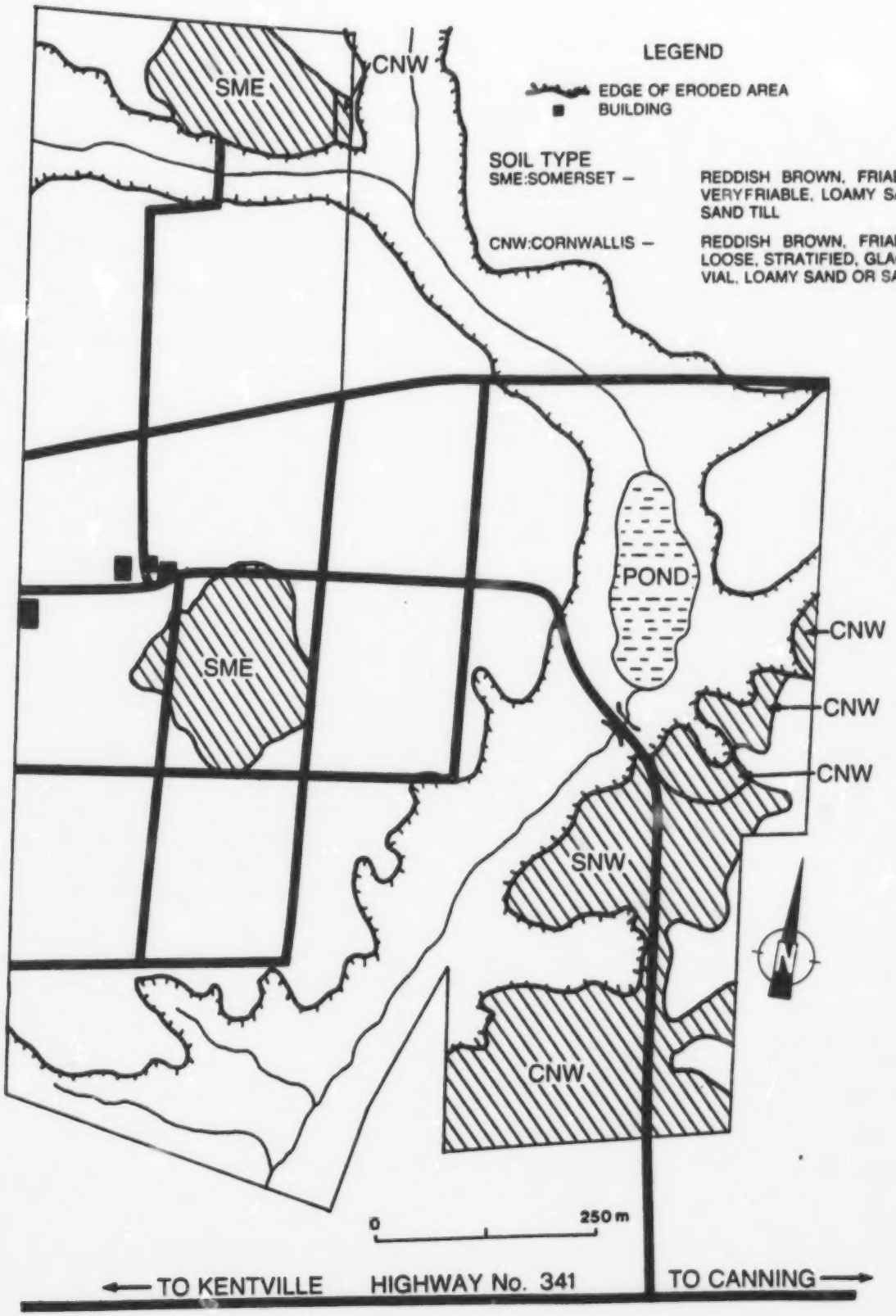


FIG. 5 CORNWALLIS AND SOMERSET SOIL SERIES

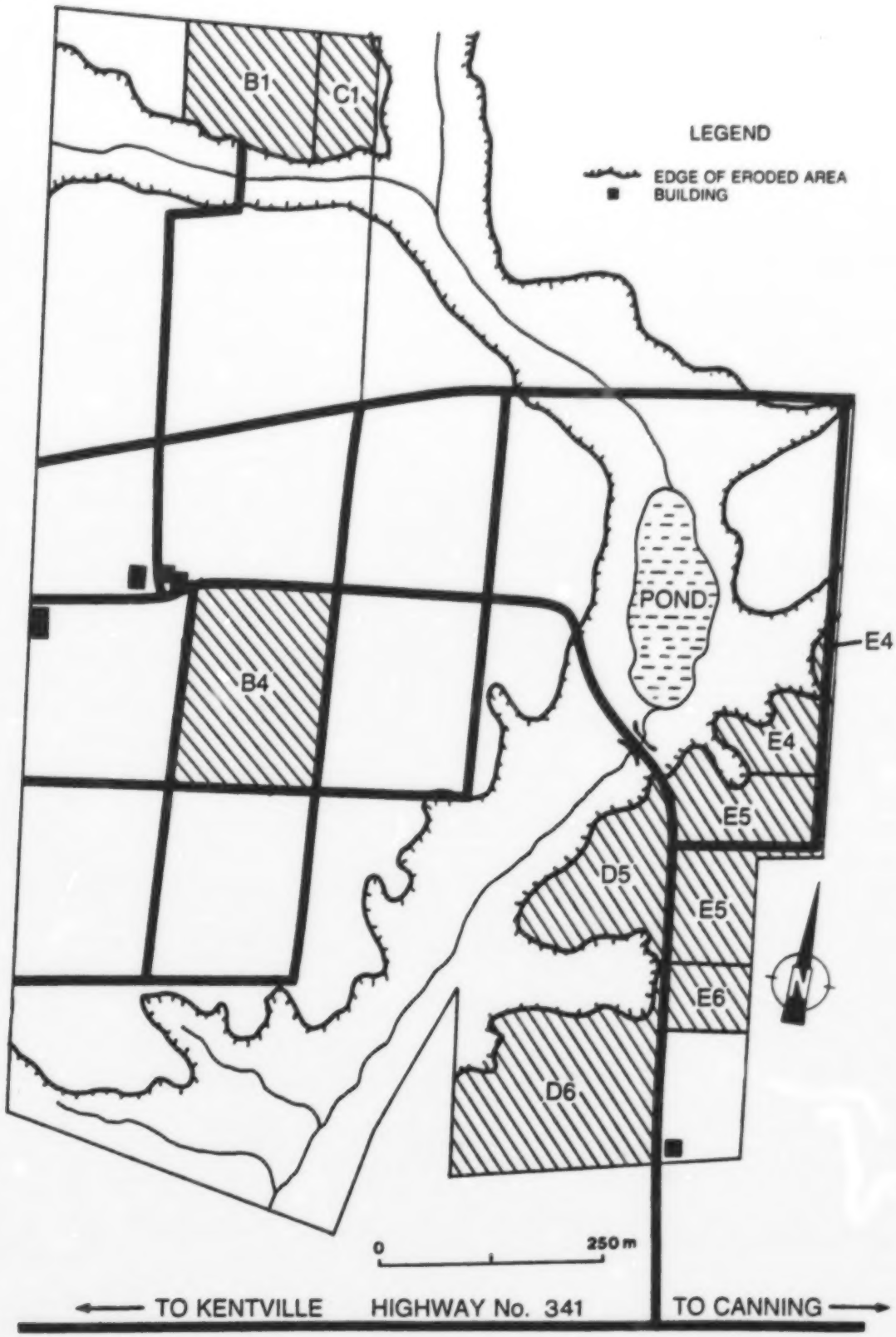


Fig. 6 POTENTIAL SITES FOR PESTICIDE APPLICATIONS

3.0 PROPOSED EXPERIMENTS

Specific experiments have not yet been designed, however, several ideas are under consideration. Jackson (1988) describes a field experiment which could feasibly be undertaken with the cooperation of Agriculture Canada. This would be intended to demonstrate the effect of various cropping practices on the fate of aldicarb. Results of a four-year long monitoring program of aldicarb contamination of the groundwaters in the sandstone aquifer of Prince Edward Island have suggested that contamination has arisen because of inadvisable agricultural practices. It is common practice to apply the seed potatoes together with the pesticide (Temik) and fertilizer during the early spring. Because Temik is a systemic pesticide, it relies on the presence of a well-developed root zone for plant uptake. However, this is clearly impossible at this point in time when no root zone has developed.

Furthermore, the acidity and coldness of the soil waters after snowmelt in May would inhibit the degradation of aldicarb to less toxic degradation products. Finally, the oxidation of ammonium nitrate fertilizer would produce an acid soil water which would increase the persistence of aldicarb. Consequently, in the U.S.A. it is the practice to apply aldicarb only after plant emergence, i.e., in late June, when the soil is drier, considerably warmer, and less acid.

Therefore, it is proposed that after characterizing the groundwater flow and chemistry, separate plots of potatoes be cultivated at Sheffield Farm, e.g., in the B1/C1 field area, and that fertilizers and aldicarb be applied (1) at seeding and (2) after emergence to identical plots. This experiment should provide information on the safe use of this very toxic insecticide. Furthermore, it should indicate how fertilizer residues may contaminate groundwaters.

A second experiment could concern the use of insecticides or fumigants (e.g., dichloropropane/ene) that have been detected in groundwaters beneath berry fields in British Columbia. A third could involve the application of atrazine to corn crops. The Commercial Chemicals Branch of Environmental Protection indicates that there are some herbicides still at the preregistration stage which could be reviewed as potential experimental subjects. In each case the intent of the study would be to understand the migration and fate of the pesticide with respect to plant uptake, hydraulic transport through the unsaturated zone sorportion and transformation in both the saturated and unsaturated zones of the groundwater flow systems and, finally, the fate of the pesticide once it has reached the water table and enters the saturated zone of the flow system.

4.0 STUDY PLAN

Studies will be conducted in two phases over a period of at least five years. The proposed field experiments will be conducted upon completion of support activities such as background data compilation, instrumentation, sampling and testing, review and interpretation.

Outputs will include year-end progress reports, reports by other involved participants, and one final document with recommendations.

Phase I of the aquifer vulnerability study was begun in fiscal year 1988/89. Phase I and II are further discussed here.

4.1 Phase I (1988-1990)

Years one and two are dedicated to site characterization and design of specific experiments. This involves establishing hydrogeological and hydrogeochemical site conditions including the groundwater flow regime, the physical and chemical nature of the earth materials (soils, overburden and bedrock), the ambient groundwater quality, both inorganic and organic (especially pesticides) and land use practices (notably agrichemical applications). Experimental design will involve selection of pesticides and fertilizers to be applied, and determination of additional monitoring points (e.g. variable depth piezometers and lysimeters). A computerized data base will be developed and GIS technology (SPANS) will be employed.

It is proposed that additional instrumentation be installed during 1989 in those sites that appear suitable for field experiments and that experimental applications of pesticides to crops begin the spring of 1990.

Work in 1989/90 will focus on further development of piezometers, the collection of at least 3 sets of water samples to analyse for organo phosphates, organo chlorides, triazenes, carbamates, nitrates, TOC and general inorganic parameters. Analyses of up to 80 samples will be conducted by the Water Quality Branch in Moncton with assistance from NWRI in Burlington. Water level monitoring, geophysical surveys and hydraulic evaluations will be carried out in addition to any associated work to be conducted by Agriculture Canada or other agencies such as TUNS.

A steering committee chaired by the Water Planning and Management Branch has been established. The committee will meet on a regularly scheduled basis. Working groups have been formally established by each agency involved in the Sheffield Study and a contact person appointed. Appendix 2 lists the agencies and participating staff. The working groups will deal with technical issues and activities while the steering committee will deal with overall project goals and objectives.

4.2 Phase II (1990-1994)

The analysis of data gathered in Phase I is necessary for the design of the field experiments and monitoring comprising Phase II. Recommendations will focus on which pesticides to apply, where to apply them and under what conditions, including timing. Subsequent hydrogeologic work necessary to support the field experiments will also be carried out in Phase I.

5.0 RESOURCES

Various agencies are contributing to the resources required to carry out the Aquifer Vulnerability Study. These include operating money, person years or services (such as the provision of storage space). Contributors of resources include the Water Planning and Management and Water Quality Branches of Inland Waters (Atlantic), the National Water Research Institute, the National Hydrologic Research Institute, the Commercial Chemicals Branch of Environmental Protection (National Capital Region), Agriculture Canada, the Baseline Studies Fund and the PEST FUND. The budgets for the 1988/89 fiscal year and a tentative budget for 1989/90 are summarized in Table 1.

6.0 ACKNOWLEDGEMENTS

Inland Waters appreciates funding support of the Commercial Chemicals Branch, Environmental Protection; assistance with study design and implementation from Dr. Richard Jackson (NWRI) and Mr. Jamie Mutch, Department of Civil Engineering, University of New Brunswick; the de Geus family on the Sheffield Farm for their advice and field assistance. Special thanks is extended to Agriculture Canada staff for their very valuable field support including a secure dedicated field office established in June 1989 at the Sheffield Farm.

TABLE 1

BUDGET SUMMARY FOR 1988/89 AND 1989/90

1988/89

Agency(Source)	PY	O&M	Capital
WPM (Atlantic)	1.7	21K	3K
WQB (Atlantic)	.1	2K	-
NWRI	.2	4K	-
EP (Commercial Chemicals Branch	-	15K	-
Baseline Studies	-	3K	-
TOTALS	2.0 PY	45K	3K

1989/90 ESTIMATE

Agency (Source)	PY	O&M	Capital
WPM (Atlantic)	0.8	12K	4K
PEST Fund	-	20K	-
WQB (Atlantic)	1.1	15K	-
Baseline Studies	-	2K	-
Ag. Canada	0.1	2K	-
NHRI	0.1	4K	-
NWRI	0.2	2K	-
TOTALS	2.3	57K	4K

7.0 REFERENCES

Jackson, R.E., 1988. Aquifer Vulnerability Studies, Annapolis Valley, Nova Scotia; A discussion paper. NWRI contribution, RRB-88-72.

Langille, D.R., 1987. Soils of the Kentville Research Station and Sheffield Farm, Research Branch. Agriculture Canada, Kentville, Nova Scotia.

Trescott, P.C., 1968. Groundwater Resources and Hydrogeology of the Annapolis- Cornwallis, Nova Scotia. Memoir 6, Nova Scotia Department of Mines, Halifax, Nova Scotia.

APPENDIX 1

MEMORANDUM OF UNDERSTANDING

MEMORANDUM OF UNDERSTANDING

General

With the recent emergence of environmental and health concerns related to the use of agricultural chemicals and their subsequent occurrence in groundwater the need for a joint cooperative approach is required to address this issue. This Agreement outlines a mutual arrangement to assist in the assessment of the fate of agricultural chemicals in the environment, particularly in relation to surface water and groundwater. Under this arrangement both parties agree that:

1. This is a five year Agreement which may be terminated by either party giving 30 days notice to the other party.

2. That both parties acknowledge an interest in the topic and mutually agree to cooperate in carrying out the field, analytical and interpretive work to address this issue.

Conservation and Protection Atlantic Agrees to:

1. Establish piezometers as part of the monitoring network and to collect data;

2. Work within the confines of Agriculture Canada's Research Farm at Sheffield Mills and respecting their land use and other research projects;

3. Provide a progress and status report to the Research Station on an annual basis; and

4. Clean up and restore sites and remove instrumentation within six months of expiry of this Agreement.

The Research Branch, Agriculture Canada Agrees to:

1. Give Conservation and Protection Atlantic access to agricultural land for the purpose of their research work;

2. Provide an assessment of historical and current pesticide and fertilizer use patterns on the farm;

3. Provide technical assistance and support with respect to sampling for chemical analyses, water level monitoring, analytical services and other logistical support, subject to available resources;

4. Inform Environment Canada of any damage to instrumentation or spills of agricultural chemicals in the area of study; and

5. Withold release of any information and results which pertain to these studies, except as authorized by Environment Canada.

Signed on the 8th day of September 1988 by:

Mr. J. E. Vollmershausen
Regional Director General
Conservation & Protection

Dr. M. Weaver
Director
Kentville Research Station

A P P E N D I X 2

PROJECT PARTICIPANTS

INLAND WATERS DIRECTORATE

WATER PLANNING AND MANAGEMENT BRANCH

MAILING ADDRESS: 45 Alderney Drive
15th. Floor
Dartmouth, Nova Scotia
B2Y 2N6

FAX NUMBER: (902) 426-4457

PARTICIPANTS:

Mr. T. W. Hennigar
Co-ordinator
Groundwater Activities
C&P Atlantic
(902) 426-3266

Mr. D. C. Ambler
(Project Manager 1989/90)
(902) 426-1701

Mr. J. E. Gibb
(902) 426-1698

Mr. F. Cruickshanks
(Co-ordinator Field Activities)
(902) 426-6885

Mr. J. Hennigar
(Summer Student '88-'89)
(902) 426-6885

Ms. A. Napke
(Summer Student '89)
(902) 426-6885

Mr. D. Walker
(TUNS Master Thesis Student)
(902) 426-6885

INLAND WATERS DIRECTORATE

WATER QUALITY BRANCH

MAILING ADDRESS: P.O. Box 861
Moncton, New Brunswick
E1C 8N6

FAX NUMBER: (506) 857-6608

PARTICIPANTS: Dr. T. L. Pollock
(506) 857-6606

NATIONAL HYDROLOGY RESEARCH INSTITUTE

MAILING ADDRESS:	11 Innovation Boulevard Saskatoon Saskatchevan S7N 3H5
FAX NUMBER:	(306) 975-5143
PARTICIPANTS:	Dr. W. Nicholaichuk (306) 975-5748
	Mr. J. A. Gilliland (306) 975-5742

NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT

MAILING ADDRESS:	P.O. Box 2107 Halifax, Nova Scotia
FAX NUMBER:	(902) 424-0503
PARTICIPANTS:	Dr. C. L. Lin (902) 424-5300
	Mr. A. Cameron (902) 424-5300

TECHNICAL UNIVERSITY OF NOVA SCOTIA

CENTRE FOR WATER RESOURCES STUDIES

MAILING ADDRESS: P.O. Box 1000
1360 Barrington Street
Halifax, Nova Scotia
B3J 2X4

FAX NUMBER: (902) 420-7551

PARTICIPANTS: Dr. D. H. Waller
(902) 420-7853

Dr. M. G. Satish
(902) 420-7755

Dr. W. C. Hart
(902) 420-7611

Dr. Hans Viziri
(902) 420-7520

Dr. D. Thirimuthi
(902) 420-7685

AGRICULTURE CANADA

MAILING ADDRESS:	Kentville Agricultural Centre Kentville, Nova Scotia B4N 1J5
FAX NUMBER:	(902) 678-9855
PARTICIPANTS:	Dr. R. Blatt (902) 678-2171 Ext. 218
	Dr. David Webster (902) 678-2171

ENVIRONMENTAL CHEMISTRY

VICTORIA GENERAL HOSPITAL

MAILING ADDRESS: 5788 University Avenue
Halifax, Nova Scotia
B3H 1V8

FAX NUMBER: (902) 428-2123

PARTICIPANTS: Dr. R. McCurdy
(902) 428-3464

Mr. D. Moore
(Dalhousie Master Thesis Student)
(902) 428-3464